Farabee, W. C. | F | Inheritance of digital malformations in man. (1905)

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BY

WILLIAM C. FARABEE.

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WITH FIVE PLATES

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CAMBRIDGE, MASS.

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## NOTE.

THIS paper is a brief extract from a thesis by Dr. Farabee on Hereditary and Sexual Influences in Meristic Variation, accepted in 1903 for the degree of Doctor of Philosophy in the Divison of Anthropology of Harvard University. It embodies only that part of the thesis which gives the results of Dr. Farabee's personal research on the Inheritance of Digital Malformation in Man.

For the means of carrying on this investigation as well as for the publication of this paper we are indebted to a Friend of the Museum.

F. W. PUTNAM,
Curator of the Museum.

CAMBRIDGE, MASS.,
MARCH 10, 1905.

# INHERITANCE OF DIGITAL MALFORMATIONS IN MAN.

A great deal has been written concerning the abnormities of the hands and feet, and numerous cases of polydactylism, syndactylism, ectrodactylism, and macrodactylism have been recorded; but, very few cases of hypophalangia or hyperphalangia have ever been noted. The following case of hypophalangia, or diminution in the number of phalanges, came under my notice a few years ago in Pennsylvania. After careful examination the anomaly was found to be interesting not only as a case of anatomical variation, but also as a study in heredity. All the digits of all extremities of thirty-seven persons are affected and the anomaly is inherited in conformity with Mendel's law for five generations. Measurements, tracings, photographs, radiographs, plaster casts, and complete genealogical tables, were made.*

As shown by the photograph (Plate XXIII), the people appear perfectly normal in every other respect and seem to suffer very little inconvenience on account of the malformation. The ladies complain of but one disadvantage in short fingers, and that is in playing the piano; they cannot reach a full octave and hence are not good players. Among the men are farmers, mechanics, business men, and school teachers. One man is at the head of a commercial school and a very excellent penman; another is catcher for the city baseball team. The hands and feet have the normal number of digits and the digits have the normal proportions, each to each. The thumbs and great toes have the normal number of phalanges, but the first phalanx

*I acknowledge my especial obligation to Prof. F. W. Putnam under whose direction this study was carried on.

in each case is greatly reduced in length,—so much so, especially in the thumbs, that they are said to have "double jointed thumbs." The radiograph (Plate XXVI) shows the first phalanx to be about 12 mm., and the distal 22 mm., respectively in length. Hence, the thumbs thus shortened have the same relation to the other two phalanged digits that exists in the normal hand. Each of the fingers has but two phalanges instead of three. The metacarpal bones are normal except in length, being reduced in relative proportion to the length of the digits. The following table gives the length in millimeters of metacarpals and phalanges.

TABLE I.

Length of Metacarpals and Phalanges.

| | METACARPAL. | PROXIMAL. | MIDDLE. | DISTAL. |
|---|---|---|---|---|
| Thumb | 34 mm. | 12 mm. | – – | 22 mm. |
| Index | 55 " | 30 " | – – | 15 " |
| Middle | 55 " | 40 " | – – | 15 " |
| Ring | 46 " | 32 " | – – | 15 " |
| Little | 42 " | 22 " | – – | 18 " |

The length of the hand is 162 mm., and the width 94 mm. In a few cases the distal phalanx of the ring finger is not in line with the proximal, but inclines toward the middle finger.

The hands of all are broad, thick, and pulpy, as is seen in the photographs of the hands (Plates XXIII, XXIV, XXV). The joints of fingers and toes, as appeared on examination and as shown by the radiographs (Plates XXVI, XXVII), are loosely articulated. This may account for the lack of strength in the hands which was spoken of by many. One man, who has been a noted wrestler, said that his defeats were due to his weak hands. The table II also shows a weak grip. This, however was not a fair test as the instrument used was too wide for their short hands.

The feet, as shown in the cast and the outlines of the radiograph (Plate XXVII), do not outwardly appear abnormal. The toes are slightly shorter and the foot a little thicker than normal but not enough so to attract attention. The bones, however

as seen in the radiograph, present precisely the same condition as already noted in the hands and all that has been said in regard to the relative length of digits and phalanges in the hands applies equally to the feet. No dissections have been made of the hands or feet, hence we are deprived of the light that the musculation might throw upon the question of which is the missing phalanx; but, judging from the length, size and form of the proximal bones, especially the size and form at the base, it appears that the bases of the distal phalanges articulate with the heads of the first row. Yet one is hardly justified in saying that either the one or the other segment is missing. It is safer to say, simply, that there is a reduction in the number of phalanges.

On account of the reluctance to submit to examination, I was able to take measurements of only three adult males, one adult female, and some children. The numbers measured are too few for the results to be of any particular value, except to give some notion of their relation to the measurements of normal individuals. Those measured are fairly representative of all families. We give, in table II, the measurements of the female and the average of the three males. There was very little variation in the males. The height of the males, 159 cm. or 5 ft. 3 in., is much below the average height of normal men. In the table of measurements, I have placed normal measurements secured by calculating the proportions of a normal individual of the same height. The average span of the arms, or reach of the males is but 146 cm. while normally it should be 165 cm. The reach is 92% of the height against 104% in normal man. The reach of the female is but 86.6% of the stature. As will be seen, the reduction in the number of phalanges does not account for all this difference in reach. It is distributed almost equally between the arm, forearm, and hand. The difference in reach is 19 cm.; in whole arm, 9.5 cm.; in upper arm, 3.1 cm.; in forearm, 3.2 cm.; and in the hand 3.2 cm. The reach diminished by the sum of the lengths of the arms would leave the width of the body about normal. On account of the short arms the body has the appearance of being very long, but by consulting the table it will be seen that the height

sitting is very nearly normal. The length of the foot is only 2 cm. short. The weight, however, is 16 lbs. heavier than normal. There does not appear to be complete correspondence between the upper and lower extremities. The upper are shorter than normal in every part whereas the lower are about normal in every way except the number of phalanges. There has never been a single instance of partial inheritance, but in all cases all extremities have been affected in precisely the same way. This is a most excellent example of similar and simultaneous variation in both extremities.

TABLE II.

MEASUREMENTS.

| | Males. | | Females. | |
|---|---|---|---|---|
| | NORMAL. | ABNORMAL. | NORMAL. | ABNORMAL. |
| Length of head | | 18.8 cm. | | 18 cm. |
| Width " " | | 15.0 " | | 15.2 " |
| " " face | | 13.5 " | | 13.6 " |
| Cephalic index | | 80 | | 84 |
| Height | 159 cm. | 159 cm. | 150 cm. | 150 cm. |
| " sitting | 85 " | 83 " | 82 " | 78 " |
| Reach | 165 " | 146 " | 156 " | 130 " |
| Length of arm | 71.5 " | 62 " | 67 " | 58 " |
| " forearm & hand | 43.4 " | 37 " | 41 " | 34 " |
| " 2nd finger | 7.9 " | 6.4 " | 7.4 " | 5.7 " |
| " Hand | 18.8 " | 15.6 " | 17.1 " | 14.2 " |
| Width of hand | 8 " | 9.3 " | 7 " | 7.6 " |
| Length of foot | 25 " | 23 " | 23.6 " | 20 " |
| Width " " | 9.2 " | 9.9 " | 8.2 " | 8.6 " |
| Grip | 48. kgm. | 28 kgm. | 25 kgm. | 12 kgm. |
| Weight | 139 lbs. | 155 lbs. | 129 lbs. | 144 lbs. |

The family tradition is, that the first person having short digits came from Normandy in the army of William the Conqueror, and remained in England; that persons with short fingers have never intermarried; that every other child born

of a short fingered parent has short fingers; and that no long fingered descendant of a short fingered parent ever had short fingered children. There is no historic evidence, so far as I can learn, to support the first part of the tradition; it may, or may not, be true. The fact that there is a tradition concerning the anomaly, without accounting for its origin, may be taken as partial proof that the origin is so remote that it has been forgotten. The second part that exogamy has been the custom, is true for at least five generations, as will be seen in table V. It would be very interesting indeed if this part of the tradition should be violated.

## HEREDITY.

Probably the most important part of this study is that relating to the remaining portions of the tradition concerning heredity. At present the question of heredity is one of live interest on account of the testing of Mendel's discovery, — the law of heredity. The present case demonstrates the fact that the law operates in man as well as in plants and the lower animals. The abnormality here is shown to be the dominant character. The tradition that "*every other* child has short fingers," is not quite true; yet, as nearly as possible, half the offspring have the anomaly. This is in perfect conformity with the law, the underlying principle of which is the purity of germ-cells and their production in equal members. When there is a union of normal and abnormal individuals, the abnormals producing germ-cells N and A in equal numbers, the chances are equal that germ-cell N of one sex may unite with germ-cell N of the opposite sex, or that germ-cell A of one sex may unite with germ cell N of the opposite sex. Since the abnormal character is shown to be dominant, the chances are even that the offspring may be normal or abnormal. According to the laws of chance we should not expect that every other child would be abnormal, as in the tradition, but we should expect the total number of normals and abnormals in a large series to be very nearly equal, and that is what we find to be true here.

## TABLE III.

ORDER OF BIRTH AND SEX.

| GENERATION. | FAMILY. | ABNORMAL PARENT. | OFFSPRING. |
|---|---|---|---|
| I | | Unknown | ♀ |
| II | 1 | Female. | ♂ ♂ ♂ ♂ ♂ ♀ ♀ ♀ |
| III | 2 | Male. | ♀ ♀ ♀ ♂ ♀ ♂ ♀ ♀ ♀ ♂ ♀ ♂ |
| IV | 3 | Female. | ♀ ♂ ♂ ♀ |
| | 4 | Male. | ♀ ♀ |
| | 5 | Female. | ♀ ♀ ♀ ♂ ♀ |
| | 6 | Female. | ♀ ♂ ♀ |
| | 7 | Male. | ♀ ♀ |
| V | 8 | Male. | ♂ ♀ ♀ ♂ ♂ ♀ ♀ ♀ ♂ ♀ |
| | 9 | Male. | ♀ ♂ ♂ ♀ ♂ |
| | 10 | Female. | ♂ ♀ ♂ ♂ ♂ ♀ ♀ |
| | 11 | Female. | ♀ ♂ ♂ ♀ ♂ ♂ |
| | 12 | Female. | ♂ |
| | 13 | Male. | ♀ ♂ |
| | 14 | Female. | ♂ ♂ |

Explanation of characters:—

♂ normal male. ♀ normal female.

♂ abnormal male. ♀ abnormal female.

By referring to table III above it will be seen that normals and abnormals do alternate in a few instances; as in family 6 where there are three children; in families 7, 13, and 14, where there are but two each; and in 8 where the alternation is continued until the eighth child. But this rule does not hold in the other families. In families 9 and 10 the first three children in each are normal, while in 11 the first three are abnormal and the last three are normal. It will be noticed that the *first* child is abnormal in but three of the fourteen families, and the *second* abnormal in nine of the thirteen families. The others are about evenly divided. The total number of offspring descended from abnormals is sixty-nine of whom thirty-three are normal and

thirty-six abnormal, distributed as follows: in the second generation, four normals and four abnormals; in the third, five normals and seven abnormals; in the fourth, seven normals and nine abnormals; and in the fifth, seventeen normals and sixteen abnormals.

## TABLE IV.

### Sex Relations.

| GENERATION. | SEX OF ABNORMAL PARENTS. | NUMBER OF OFFSPRING. | NORMAL | | ABNORMAL | |
|---|---|---|---|---|---|---|
| | | | MALE. | FEMALE. | MALE. | FEMALE. |
| I | ? | ? | | | | 1 |
| II | 1 female | 11* | 4 | 0 | 1 | 3 |
| III | 1 male | 12 | 2 | 3 | 3 | 4 |
| IV | 2 males | 4 | 0 | 1 | 0 | 3 |
| | 3 females | 12 | 1 | 5 | 3 | 3 |
| V | 3 males | 17 | 4 | 4 | 4 | 5 |
| | 4 females | 16 | 6 | 3 | 4 | 3 |

Table IV shows that the abnormality is inherited through both sexes. Six abnormal male parents have twelve males, six normal and six abnormal, and twenty-one females, eight normal and thirteen abnormal; while eight abnormal female parents have nineteen males, eleven normal and eight abnormal, and seventeen females, eight normal and nine abnormal. Of the descendants of the six males, fifty percent of the males and sixty-two percent of the females are abnormal; while, among the descendants of the eight abnormal females, only forty-two percent of the males and fifty-three percent of the females are abnormal. Fifty-eight percent of all the descendants of males are abnormal, whereas only forty-seven percent of the descendants of females are abnormal. There are five and a half times as many offspring as abnormal male parents and only four and a half times as many offspring as abnormal female parents. Forty-five percent of all descendants are males and fifty-five percent, females. Yet the whole number of abnormal males

*Three are unknown.

is less than two-thirds the number of abnormal females. Of the thirty-six descendants affected, twenty-two are females and but fourteen are males, or sixty-one and thirty-nine percents respectively. Forty-five percent of all males and fifty-eight percent of all females are abnormal. It thus appears that the males are more prolific than the females; that a higher percent of the offspring of males than of females are abnormal; and the female offspring of both male and female parents are more often abnormal. The numbers here compared are too small to base conclusions upon, yet the sexual differences are so marked that they must be of some significance.

Table v gives the genealogy of the abnormals only — the number and sex of normal and abnormal offspring in each generation. It shows that exogamy has been the custom in all these generations. Table vi gives all the known normals and abnormals and proves the last part of the tradition, — that no normal descendant of an abnormal parent has had abnormal offspring. We have here three complete lines of descent from the second generation to the fifth and all descendants are known in two of these lines. In all, twenty-one normals have married other normals outside the family and have had born to them seventy children, not one of whom is abnormal. According to former theories it should be expected that the character would reappear somewhere in these lines; but according to Mendel's law, even if the character were recessive, we should not expect it to reappear at all, since these families practised exogamy. Luckily, for the testing of recession, two cousins in the third generation married and had only normal offspring. This is shown in the table by uniting two of the lines of descent to form a new one. If the character were recessive it should certainly appear here, but it does not.

It will be noticed that fourteen normal parents in the fourth generation have but twenty-eight offspring, whereas seven abnormal parents have thirty-three. This does not signify that the abnormals are prepotent, as might be inferred. The cause was explained by one of the abnormal ladies, who said: "They always pick us up first." The abnormals all along the line have married earlier in life than the normals, so that when

TABLE V.

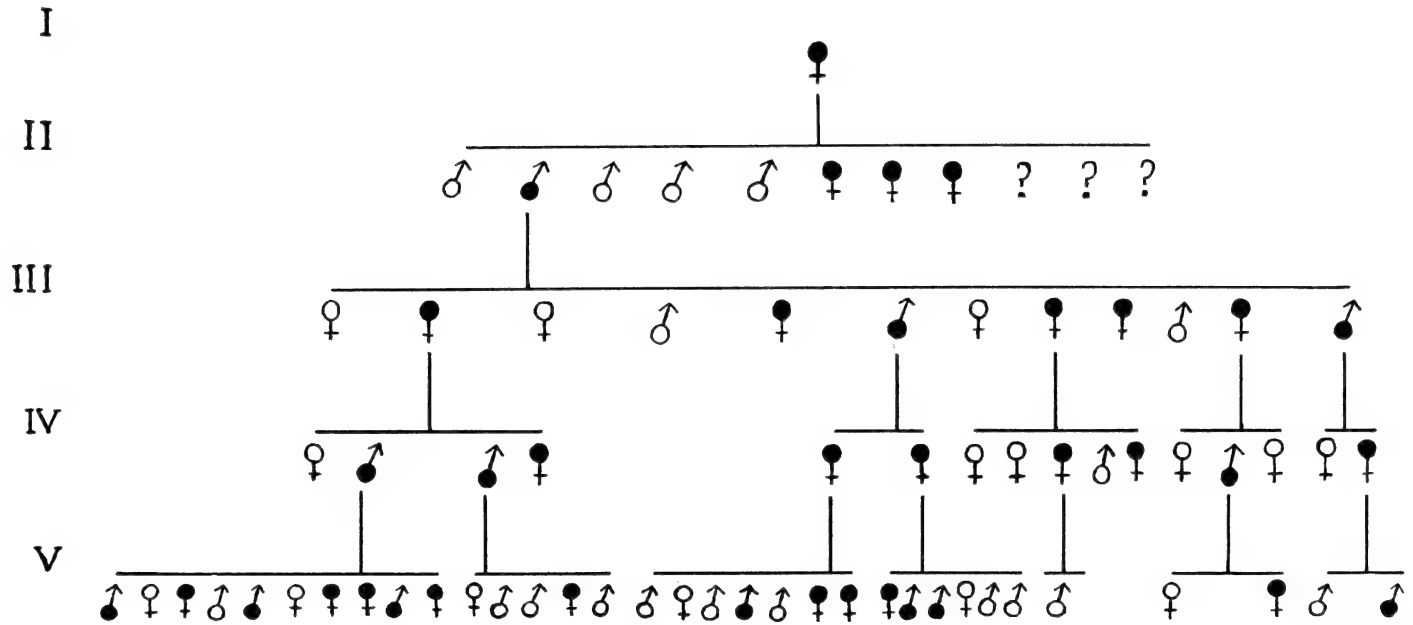
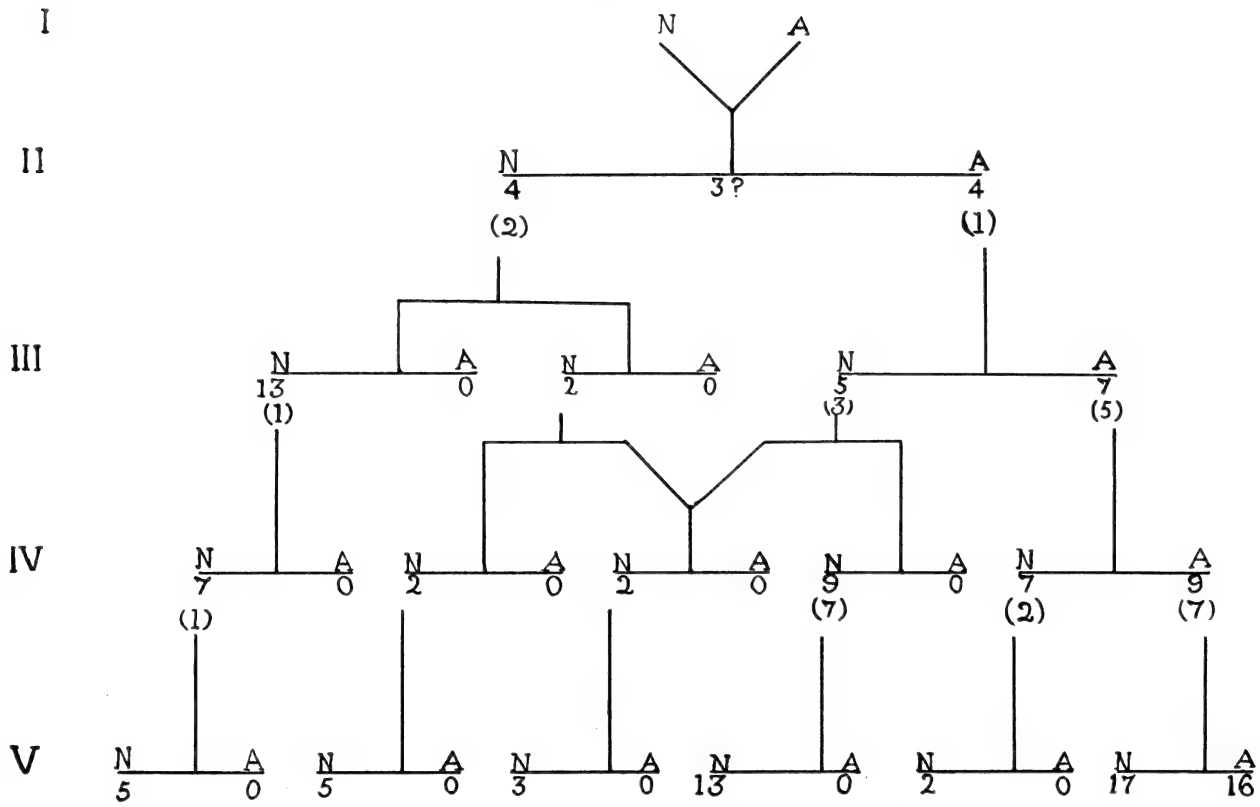


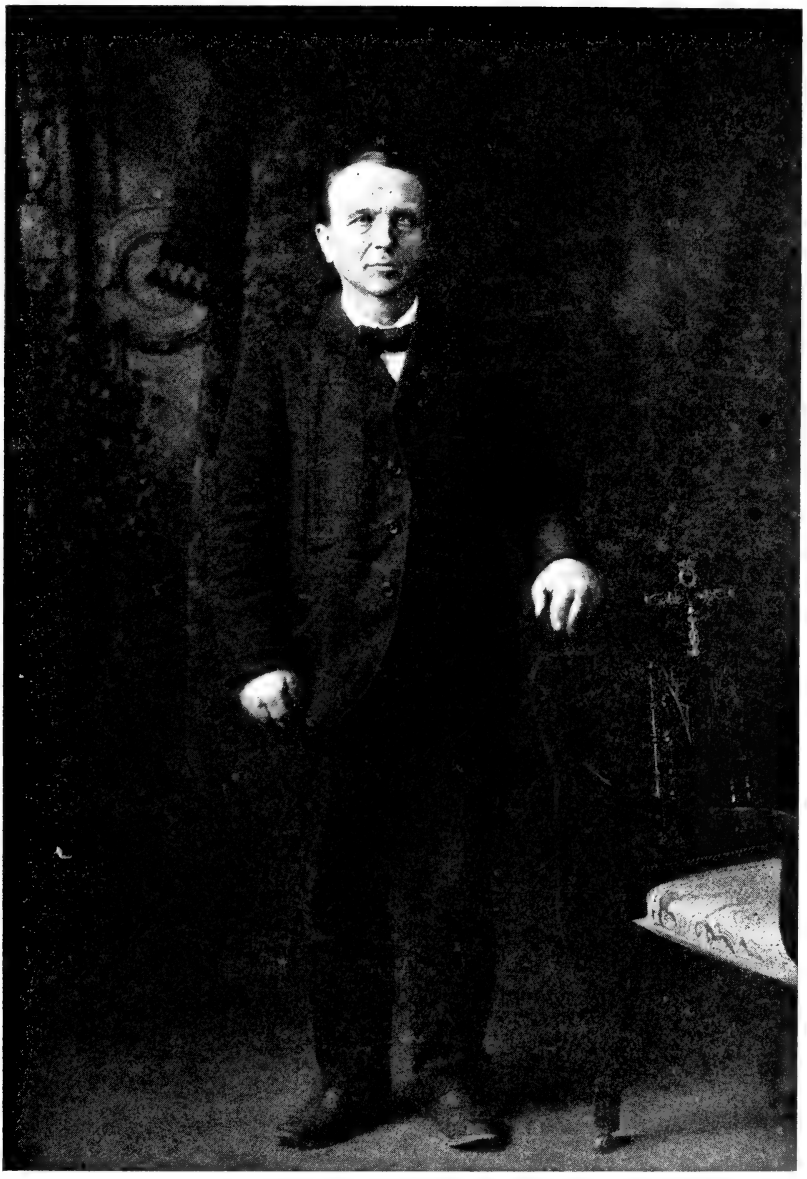
TABLE VI.



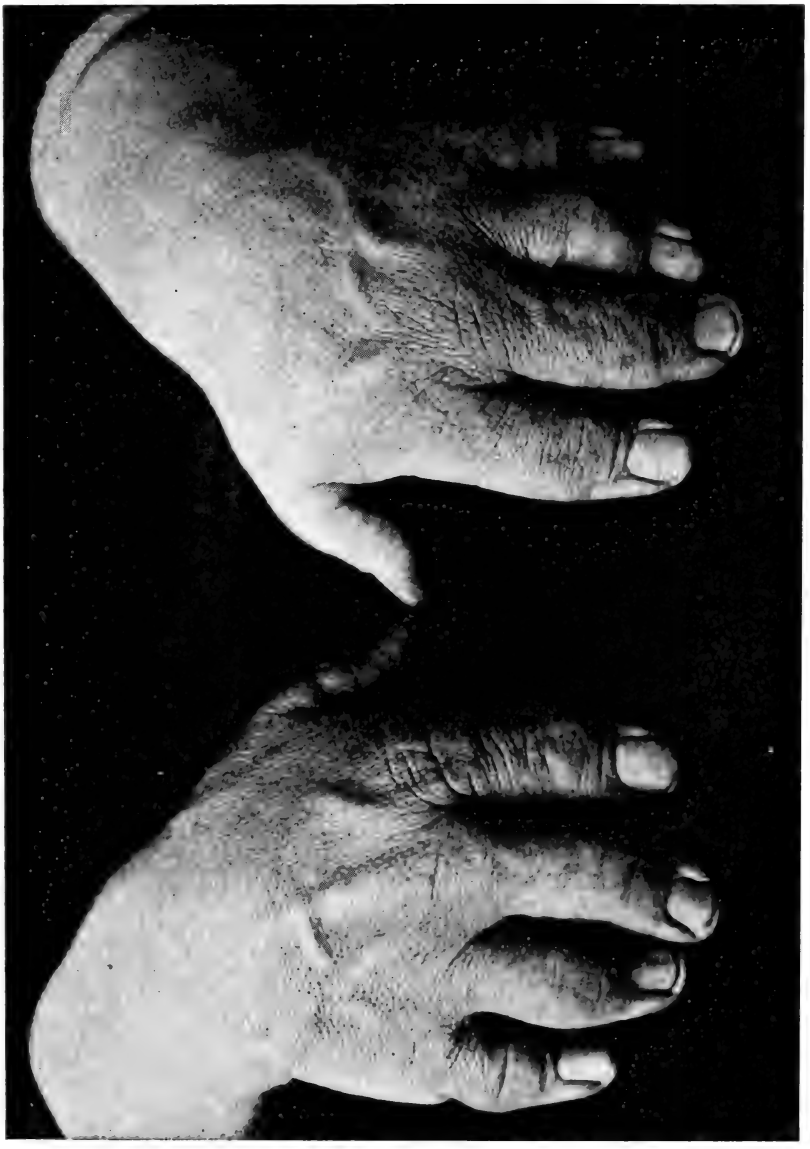

N, NORMAL. A, ABNORMAL. ( ), NUMBER LEAVING OFFSPRING.

the fifth generation is reached their families number ten, seven, five, etc., while the normals in many cases have but one child. In a short time, at the present rate, the abnormals will have gained a generation.

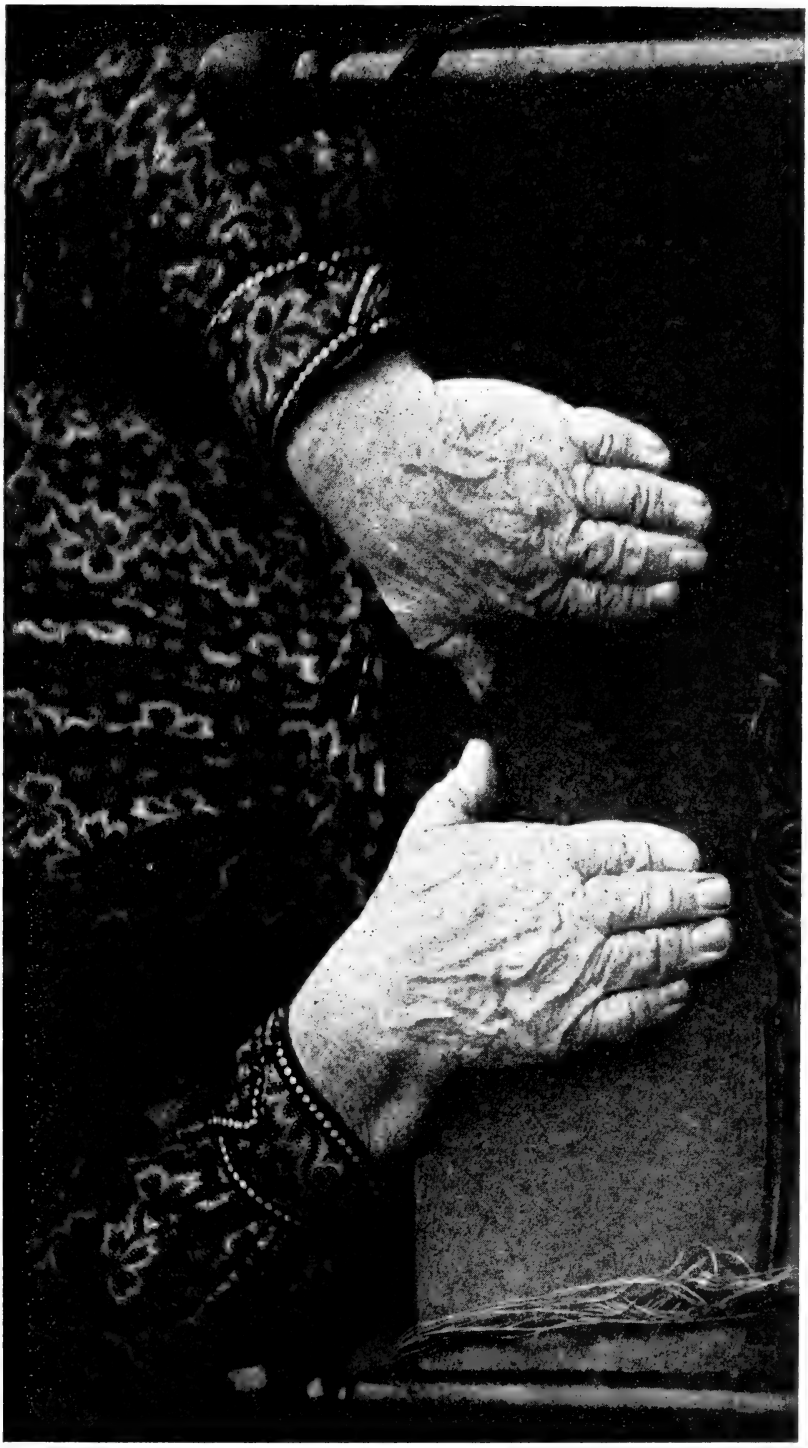
A very careful study was made to ascertain whether or not any other characteristics of an abnormal parent were inherited by the abnormal offspring. Besides the measurements taken many other things were noted; as, color of eyes and hair, form of head, facial expression, and other individual characters. The only constant accompanying characters found were the short arms and short stature. In every case the abnormal man is shorter and stouter than his normal brother, and the abnormal woman, than her normal sister. I regret that it was impossible to get a photograph of a group of normals and abnormals to show this difference in stature.



MR. A., SHOWING STATURE AND SHORT HANDS.

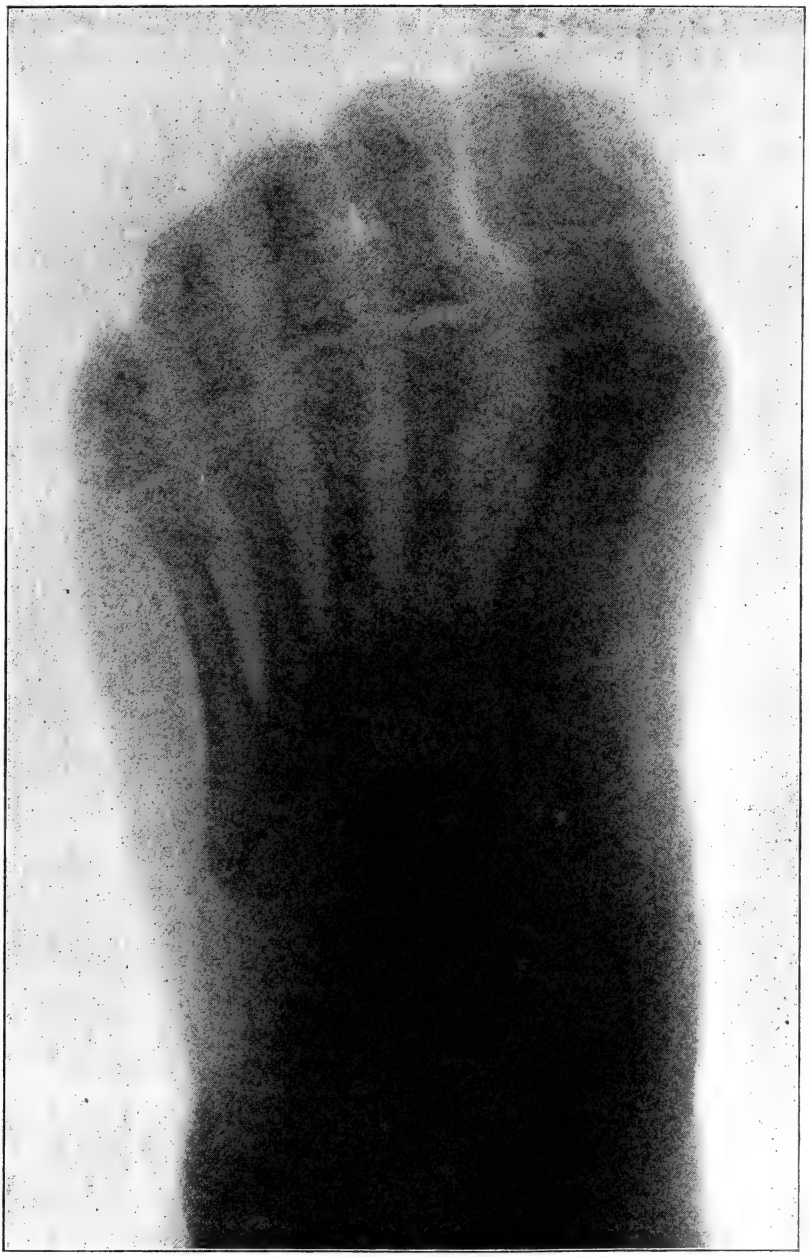


HANDS OF MR. A., SHOWING THEIR BREADTH AND THE LENGTH OF THE FINGERS.



HANDS OF MR. A'S MOTHER.

RADIOGRAPH OF THE LEFT HAND OF A'S BROTHER, SHOWING THE TWO-PHALANGED DIGITS AND THEIR LOOSE ARTICULATION. 3/5 SIZE.



RADIOGRAPH OF LEFT FOOT OF MR. A., SHOWING THE TWO-PHALANGED DIGITS. ¾ SIZE.